Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 16 (2): 461–469
https://doi.org/10.15560/16.2.461

PENSOFT

Distribution extension and first record of *Trinycteris nicefori* Sanborn, 1949 (Chiroptera, Phyllostomidae) from the state of Pernambuco, Brazil

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Abstract
This study presents the first record of *Trinycteris nicefori* Sanborn, 1949 from the Brazilian state of Pernambuco. The specimens were collected in the municipalities of Recife and São Lourenço da Mata in fragments of the Atlantic Forest. Three females were collected. The measurements and coloration pattern of these specimens are consistent with the diagnosis of the species. This record establishes a new limit for the known distribution of *T. nicefori* in Brazil, extending this range approximately 450 km to the most northeastern part of the Atlantic Forest.

Keywords
Atlantic Forest; bats; Brazilian Northeast; Niceforo's Big Eared-Bat; Phyllostominae.

Academic editor: William Corrêa Tavares | Received 29 October 2019 | Accepted 3 February 2020 | Published 17 April 2020

Citation: Silva LAM, Leal ESB , Vilar EM, Souza AQS, da Silva AS, Oliveira MAB (2020) Distribution extension and first record of *Trinycteris nicefori* Sanborn, 1949 (Chiroptera, Phyllostomidae) from the state of Pernambuco, Brazil. Check List 16 (2): 461–469. https://doi.org/10.15560/16.2.461

Introduction

Trinycteris nicefori Sanborn, 1949 is a member of family Phyllostomidae and the only species of the genus *Trinycteris* Sanborn, 1949. Considered a subgenus of *Micronycteris* Gray, 1866 until recently, *Trinycteris* was elevated to a full genus based on genetic and morphological data (Sanborn 1949; Simmons and Voss 1998; Wetterer et al. 2000).

Trinycteris nicefori is a small, foliage-gleaning

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insectivore (Kalko et al. 1996), with forearm length ranging from 35.0 to 41.0 mm and a body weight of 7–11 g (Simmons and Voss 1998; Williams and Genoways 2008). It is known to occur in Belize, Colombia, Costa Rica, Guatemala, Mexico, Nicaragua, Panama, Venezuela, French Guiana, Guyana, Brazil, Peru, Bolivia, Suriname, and Trinidad and Tobago (Williams and Genoways 2008; Tavares and Burneo 2015). In Brazil, *T. nicefori* was initially thought to occur only in the Amazon region (Simmons 2005), although it has now been recorded in 13 Brazilian states, including Amazon–Cerrado transition areas and in the Atlantic Forest (Nunes et al. 2005; Paglia et al. 2012; Brito and Bocchiglieri 2012). Thus, it seems to prefer mesic environments and is relatively intolerant to arid conditions (Rocha et al. 2013, 2015). It is absent from the Caatinga and Cerrado biomes (Lima et al. 2018). In the states of Bahia and Sergipe in northeastern Brazil, this species has been found only in the Atlantic Forest domain (Faria et al. 2006; Faria and Baumgarten 2007; Brito and Bocchiglieri 2012; Lima et al. 2018).

We provide the first records of this bat species from the Brazilian state of Pernambuco and the third and fourth records from the Northeastern Region of Brazil, based on three specimens captured in the Pernambuco Center of Endemism, which is a region that encompasses the fragments of Atlantic Forest north of the São Francisco River (Feijó and Langguth 2013).

Methods

Three adult female were collected in two areas of Atlantic Forest in Pernambuco, northeastern Brazil, using mist nets as described below. Permits to capture and handle the species were provided by the Brazilian environmental agency (SISBIO license number 43153-2, MMA, IBAMA and ICMBIO).

These records are part of the monitoring project "Implantation of a Fauna Monitoring Program for the route of the Recife II/Pau Ferro Transmission line", and of the biodiversity research program "Research Program in Biodiversity (PPBio) – Atlantic Forest Network, Northeastern Sector, Pernambuco Site". The areas surveyed are located within the Atlantic Forest domain and have a warm and humid climate, type As′ in the Köppen classification system, with mean annual temperatures between 24.2 °C and 29.5 °C and annual precipitation of 1634.5–1845.7mm.

The first site was surveyed at Engenho Tapacurá, a farm with a predominance of sugarcane plantations and some small remnants of Atlantic Forest. The forest here is characterized as secondary forest, with a few trees remaining from the primary forest, and habitats in varying degrees of preservation.

The second site surveyed was in the Dois Irmãos State Park (Parque Estadual de Dois Irmãos: PEDI), a protected area of 1,158.51 ha (state decree no. 40,547, of 28 March 2014) in the northwestern zone of the city of Recife (Weber and Rezende 1998; Lima and Corrêa 2005). This area is one of the largest urban fragments of Atlantic Forest in this state (Ramos et al. 2006) and includes the city's zoo and a complex formed by three dams that serve as the local water supply (Coutinho et al. 1998). The vegetation is classified as Dense Ombrophilous Forest (IBGE 2012), which is in a secondary stage of succession, in which three distinct strata can be observed, with a canopy that reaches 20 m in height. The PEDI is located within an urban matrix, in a densely populated region, but is nevertheless still considered to be an important remnant of the Atlantic Forest within the Pernambuco Center of Endemism.

During the project "Implantation of a Fauna Monitoring Program for the route of the Recife II/Pau Ferro Transmission line", bats were captured using 10 ground-level mist nets (12 m × 2.5 m) set on expected bat flight routes. These nets were opened just after sunset and remained active for 7 hours each night over 15 days in each season (dry and rainy). In the PPBio surveys, 11 mist nets (12 m × 2.5 m) were used, set at ground-level and interspersed within the permanent plots of the PPBio-PEDI module, which was established using the RAPELD protocol and follow the ground contour. These nets were opened after sunset and remained open for 7 hours each night. During this project surveys were conducted on a quarterly schedule and lasted three days, covering both the dry and rainy seasons.

After capture, the specimens were handled according to the recommendations of the American Society of Mammalogists (Sikes et al. 2016), fixed in 10% formalin, and preserved in 70% alcohol. The skulls were removed and cleaned. After recording the basic external and cranial measurements (Table 1), voucher specimens were deposited in the Mammals Collection of the Federal University of Pernambuco in Recife. The body and cranial measurements were obtained with digital calipers having a precision of 0.05 mm. The specimens were identified based on Sanborn (1949), Simmons and Voss (1998), Nogueira et al. (2007), Williams and Genoways (2008), and Lima et al. (2018).

Results

New records. Brazil: Pernambuco • Engenho Tapacurá (08°00′S, 035°01′W, ca 160 m elev.), São Lourenço da Mata municipality, 1 adult female (Fig. 1); UFPE 3653, collected by LAM Silva, YB Valle, and MAB Oliveira, 27 September 2006 • Parque Estadual Dois Irmãos (08° 01′S, 034°52′W, 8 m elev.), Recife municipality, 1 adult female, UFPE 3654, collected by LAM Silva, AQS Souza, and AS Da Silva, 5 July 2015 • same locality, 1 adult female (Fig. 1), UFPE 3655, collected by LAM Silva, AQS Souza, and AS Da Silva, 10 October 2015.

The Engenho Tapacurá specimen was captured in one of the least impacted fragments of Atlantic Forest found within the study area. The forest matrix in the vicinity of a small reservoir is crossed by a dirt road,

Table 1. External and skull measurements (in mm) of the *Trinycteris nicefori* specimens collected during the present study and the specimens analyzed by Rocha et al. (2013), Lima et al. (2018), and Delciellos et al. (2018). The body mass is given in grams and the morphological measurements are in millimeters.

	Brazil, Pernambuco (UFPE3653) ♀	**Brazil, Pernambuco (UFPE3654)** ♀	**Brazil, Pernambuco (UFPE3655)** ♀	**Lima et al. (2018) RRM07** ♀	**Lima et al. (2018) RRM126** ♂	**Delciellos et al. (2018) MN81510** ♂	**Rocha et al. (2013) MZUSP 35193, MZUSP35195** ♀	**Rocha et al. (2013) MZUSP 35194, MZUSP 35196** ♂
External measurements	*n* = 1	*n* = 1	*n* = 1	*n* = 1	*n* = 1	*n* = 1	*n*=2	*n*=2
Weight	6.9	8.5	8.5	8	6	—	—	—
Forearm length	37.0	36.5	38.0	39.68	38.0	37.00	—	—
Body length	45.0	46.5	44.0	—	—	—	—	—
Ear length	17.0	15.5	14.5	—	—	—	—	—
Tail length	2.1	8.0	12.2	—	—	—	—	—
Calcar length	—	5	4	—	—	5	—	—
Hindfoot length	12.5	11.5	10.0	—	—	—	—	—
Cranial measurements	n = 1	n = 1	n = 1	n = 1	n = 1	n = 1	n = 2	n=2
Total skull length	19.85	19.81	19.67	21.0	20	19.40	19.48–19.58	20.05–19.56
Cranial box height	8.37	8.69	8.87	7.0	7.5	—	—	—
Condylobasal length	18.76	18.52	18.9	18.5	18.0	—	18.03–18.18	18.22–18.22
Postorbital constriction	4.00	5.37	4.45	4	4	—	4.12–4.32	4.36–4.22
Breadth of braincase	8.14	8.64	8.53	—	—	—	—	—
Mastoid breadth	7.22	8.45	7.99	—	—	—	8.35–8.68	8.78–8.76
Zygomatic breadth	9.91	10.16	10.22	—	—	—	9.62–9.76	9.85–9.37
Breadth across upper molars	6.13	6.25	6.04	—	—	—	6.35–6.48	6.56–6.37
Length of mandible	13.07	13.67	13.21	—	—	—	12.81–12.98	13.52–13.13
Mandibular toothrow length	7.83	8.10	8.08	—	—	—	5.69–5.78	5.96–7.34

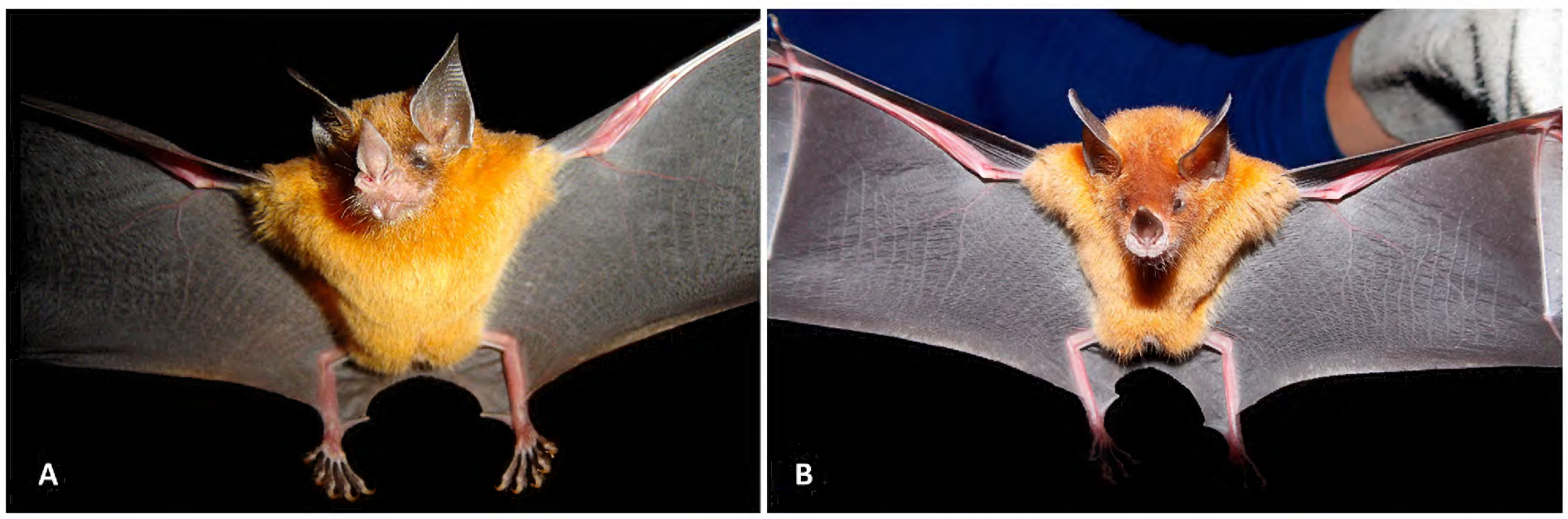

Figure 1. Adult females of *Trinycteris nicefori* **A.** UFPE 3653; Engenho Tapacurá, São Lourenço da Mata, Pernambuco. **B.** UFPE 3654; Parque Estadual de Dois Irmãos, Recife, Pernambuco.

intersected by numerous trails, and surrounded by sugarcane plantations (Ramos and Araújo 2006). The vegetation there is relatively dense, with tree heights ranging from 5 to 8 m and high frequency of species typical for the region, in particular, *Sloanea guianensis* (Aubl.) Benth (Elaeocarpaceae), *Parkia pendula* (Willd.) Benth. ex Walp. (Leguminosae), *Dialium guianensis* (Aublet.) Sandwith. (Caesalpiniaceae), *Brosimum guianense* (Aubl.) Huber (Moraceae), and *Tapira guianensis* Aubl. (Anacardiaceae).

The Parque Estadual Dois Irmãos specimens were captured in an important protected area within the urban zone of the city of Recife. The specimens were captured in the permanent plot PE1-1500 of the PPBio module installed in the PEDI. This plot is located near the margin of the protected area, near the local community known as Estrada dos Macacos. The vegetation here is dominated by *Pogonophora schomburgkiana* Miers ex Benth., *Tovomita brevistaminea* Engl., *Paypayrola blanchetiana* Tul., *Eschweilera ovata* (Cambess.) Miers, and *Thyrsodium spruceanum* Benth. A number of *P. pendular* trees are also found within the area.

Identification. Our three specimens have pointed ears with concave outer margins. The interauricular band is absent. The nasal leaf base is fused to the upper lip. The lower lip has a pair of flat pads which are divided by a shallow groove. The calcar is shorter than the length of the foot. All three specimens have a reddish brown coat

typical of the red chromatic phase of the species (Sanborn 1949; Simmons and Voss 1998) (Fig. 1). The dorsal hairs are tricolor, with a first (basal) band which is pale, narrow, and inconspicuous, a second dark brown band, and a third darker brown (hair tip) band .The ventral pelage is slightly paler and tricolored. No dorsal stripe was observed (Simmons and Voss 1998; Reis et al. 2013; Delciellos et al. 2018). There are two pairs of upper incisors and three premolars. These incisors are not chisel-shaped but are protruding and are not aligned with the canines, being much shorter and narrower. The rostrum is shorter than the braincase. The rostrum and the anterior orbital region of the cranium are not inflated (Lima et al. 2018), and the basopharyngeal fossae are deep. The zygomatic is wider than the mastoid, and the lower incisors are trifid (Fig. 2).

Discussion

Trinycteris nicefori was classified as Least Concern by the International Union for Conservation of Nature (Tavares and Burneo 2015). It was not included in the Brazilian Red Book of endangered fauna (ICMBio/MMA 2018). Despite its ample geographic range in the Neotropical region, *T. nicefori* is infrequently sampled in mist net inventories and has been recorded at only 26 localities in Brazil (Fig. 3; Table 2). There are still many potential gaps in its distribution.

The bat fauna of the Atlantic Forest is the best-sampled of any Brazilian biome (Bernard et al. 2011), and it has the second largest number of species (120), including five which are endemic to this biome (Paglia et al. 2012; Graipel et al. 2017; Muylaert et al. 2017). Even so, many knowledge gaps persist throughout the Atlantic Forest (Bernard et al. 2011), and further inventories are needed to determine the true chiropteran diversity of this biome.

Niche modeling using climatic and vegetative variables rather than land use (see Rocha et al. 2015) predicted the occurrence of *T. nicefori* in the Atlantic Forest of Pernambuco. As it stands, this affirmation implies that if the area is severely disturbed, the model will not indicate the occurrence of the species. Our study areas have a long history of anthropogenic impacts and fragmentation, so the new records of *T. nicefori* were unexpected.

Together with the recent report of *Lionycteris spurrelli* Thomas, 1913 from the same region (Lira et al. 2009), the confirmation of the presence of *T. nicefori* in Pernambuco reinforces the need for additional surveys of the state's chiropteran fauna, in particular in impacted and fragmented habitats, in order to determine the full diversity of this fauna and the distribution of bat species in this Brazilian state.

At present, 86 bat species in eight families and 43 genera are known to occur in Pernambuco (Reis et al. 2017; Loureiro et al. 2018; Barbier et al. 2019). This tally includes 70 species in the state's semiarid Caatinga scrublands and 66 species found in the small fragments of Atlantic Forest that persist in the state. The Phyllostomidae is the most diverse family of mammals in Pernambuco, with 46 species recorded until now. Our report of *T. nicefori* increases the number of bat species known to occur in Pernambuco to 87 and the total for the state's Atlantic Forest to 67. This new records of *T. nicefori* also extend the known range of this species 450 km north and east of the nearest previously known locality, the Mata do Junco Wildlife Refuge in the Brazilian state of Sergipe. The new record from the Dois Irmãos State Park (PEDI) is the easternmost known locality of *T. nicefori* (Fig. 3).

Freitas and Silva (2014) recorded 26 bat species at Dois Irmãos during the survey for the compilation of the management plan of this protected area, which was recently expanded by more than 1,000 ha. Historically, bats were sampled in this area only in the vicinity of the zoo. As *T. nicefori* is considered to be a rare specialist species in the Atlantic Forest domain (Pires and Cadermatori 2018), the record from the PEDI indicates that a comprehensive sampling effort can guarantee a more definitive inventory of the bat diversity of an area, even in highly impacted urban forest fragments.

Acknowledgements

We are grateful to the administration of Dois Irmãos State Park (PEDI) for authorizing fieldwork work and to the PPBio for authorizing and financing the research within the scope of this research program. We would also like to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for granting master's scholarships to A.Q.S.S. through the Graduate Program in Human Health and Environment at the Federal University of Pernambuco (UFPE) and to A.S.S through the Graduate Program in Ecology at the Federal Rural University of Pernambuco; and for granting Phd's scholarships to E.S.B.L. through the PostGraduate Program in Animal Biology at the Federal University of Pernambuco (UFPE) and to E.M.V. through the PostGraduate Program in Biological Science (Zoologia) at the Federal University of Paraíba (UFPB). We are also grateful to the members of the Northeast Bat Study Group (GEMNE) of the UFPE Vitória Academic Center and the Paloma J.A. de Oliveira for assistance during fieldwork at PEDI. We thank Stephen Francis Ferrari for her support in the English revision and the two anonymous reviewers provided valuable comments and suggestions that helped improve the manuscript.

Authors' Contributions

LAMS, MABO and AQSS collected the specimens; ESBL and EMV identified the species; ESBL described the morphology of the specimens; ESBL, ASS, AQSS and EMV contributed to the preparation and formatting of the manuscript; LAMS and MABO helped correct the manuscript.

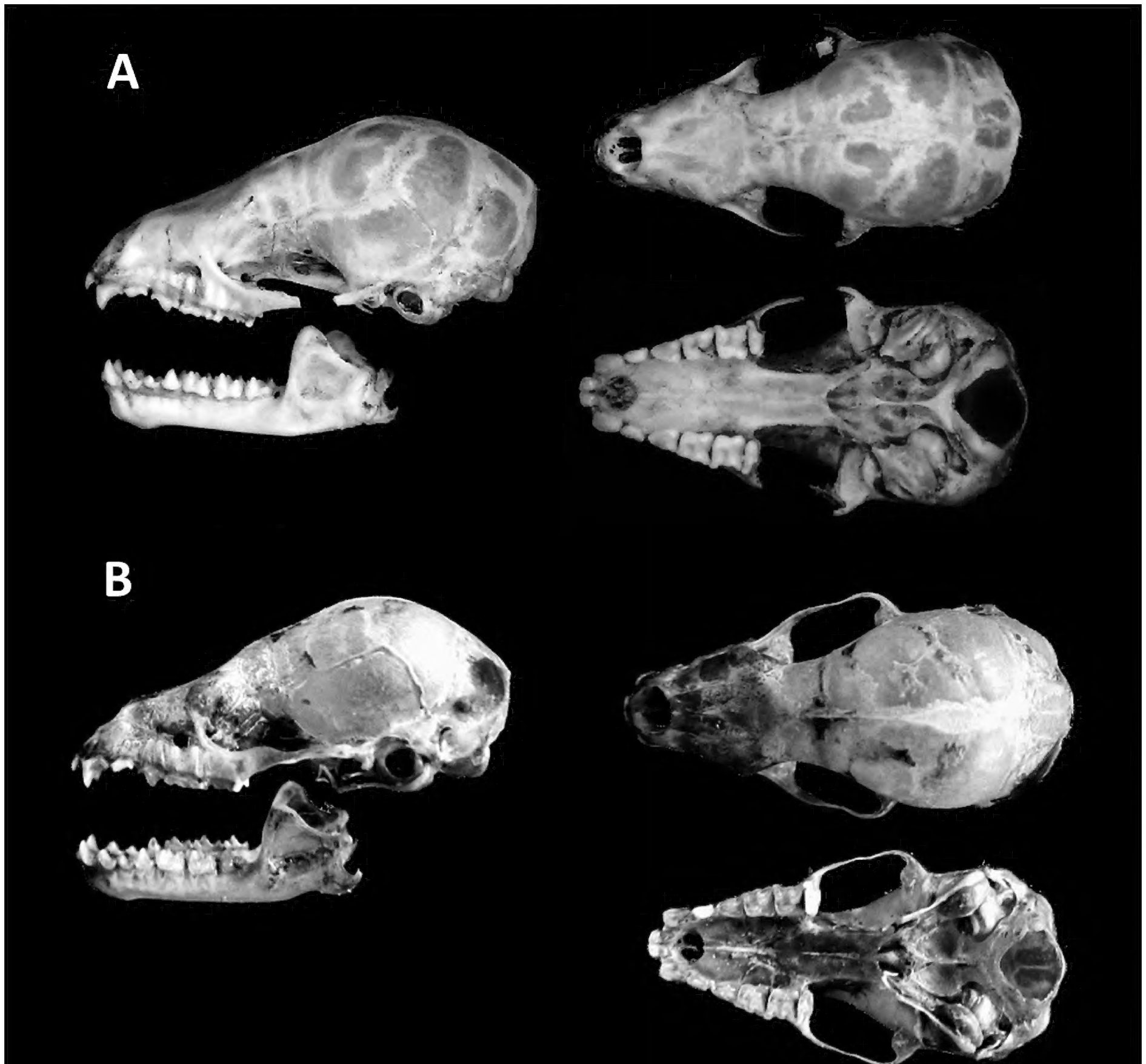

Figure 2. *Trinycteris nicefori*, adult females. **A.** Lateral, dorsal, and ventral views of the skull of UFPE 3653 from Engenho Tapacurá, São Lourenço da Mata, Pernambuco. **B, C.** Skulls in lateral, dorsal and ventral views of two adult females, UFPE 3654 and UFPE 3655, from Parque Estadual de Dois Irmãos, Recife, Pernambuco.

Figure 3. Distribution of *Trinycteris nicefori* records in Brazil. The numbers in the map coincide with those in Table 2.

Table 2. Known records of *Trinycteris nicefori* from North, Central and South America. The numerical codes refer to the points shown in Figure 3.

Location code	Latitude	Longitude	Locality	Reference
Mexico				
1	16°52′N	090°56′W	Chiapas, Yaxchilán	Escobedo and Morales et al. (2006)
Belize				
2	17°25′ N	088°77′W	Cayo-Pond, Las Cuevas Research Station	Escobedo and Morales et al. (2006)
3	16°31′N	088°49′W	Toledo, Quebrada de Oro	McCarthy and Blake (1987)
4	16°09′N	089°05′W	Toledo, Aguacate	McCarthy (1987)
Costa Rica				
5	10º10′N	085º 21′W	Cavernas llamadas La Trampa, Península de Nicoya, Guanacaste	Vásquez and Durán (2017)
6	10°25′N	084°00′W	La Selva Biological Station	LaVal and Fitch (1977)
Panama				
7	09°09′N	079°51′W	Barro Colorado Island	Giannini and Kalko (2004)
Colombia				
8	13°03′ N	067°55′W	Inírida	Ferrer-Pérez et al. (2009)
9	07°54′ N	072°31′W	North Santander, Cucuta (Type locality)	Sanborn (1949)
10	05°12′ N	074°54′W	Tolima, Mariquita	Muñoz (2001)
11	03°59′ N	077°20′W	Valle del Cauca, Bahía Málaga Naval Base	Alberico (1987)
Venezuela				
12	10°28′N	066°17′W	Trujillo 19 km N of Valera, Miranda, Birongo	Williams and Genoways (2008)
13	08°00′ N	061°18′W	Bolívar-Unidad V, Reserva Forestal Imataca	Ochoa (1995)
Trinidad and Tobago				
14	10°46′N	061°23′W	Trinidad, Las Cuevas	Carter et al. (1981)
Guyana				
15	06°00′N	058°40′W	Cuyuni-Mazaruni, Bartica, 24 miles along Portaro Road	Hill (1965)
Suriname				
16	05°43′N	054°38′W	Marowijne, Moengo, 10 kilometers N and 24 km W	Genoways and Williams (1979)
17	04°28′N	057°02′W	Bakhuis	Lim (2009)
Ecuador				
18	00°50′S	077°28′W	Orellana - Santa Rosa de Arapino	Albuja (1999)

Table 2. *Continued.*

Location code	Latitude	Longitude	Locality	Reference
French Guiana				
19	05°17′N	052°55′W	Paracou	Simmons and Voss (1998)
Peru				
20	10°06′N	071°14′W	Ucayali, Balta, Río Curanja	Voss and Emmons (1996)
21	09°21′N	075°59′W	Huanuco, Tingo María, Hotel Turistas	Bowles et al. (1979)
22	03°44′N	073°14′W	Iquitos	Klingbeil and Willig (2010)
23	03°29′N	073°03W	Loreto, Puerto Indiana	Pirlot (1968)
Bolivia				
24	13°34′N	068°44′W	La Paz	Anderson (1997)
Brazil				
25	07°23′S	073°39′W	Parque Nacional da Serra do Divisor, Acre	Nogueira et al. (1999)
26	09°37′S	065°25′W	Porto Velho, Abunã, Rondônia	Rocha et al. (2013)
27	03°36′S	054°59′W	Parque Nacional do Tapajós, Amazonas	Presley et al. (2008)
28	02°25′S	059°45′W	Manaus, Projeto Dinâmica Biológica de Fragmentos Florestais, Amazonas	Sampaio et al. (2003)
29	03°06′S	060°01′W	Manaus, Reserva Ducke, Amazonas	Reis and Peracchi (1987)
30	01°50′S	062°50′W	Parque Nacional Jaú, Amazonas	Barnett et al. (2006)
31	00°58′S	062°55′W	Barcelos, Amazonas	Moratelli et al. (2010)
32	02º49′N	060º40′W	Urban area of the Boa Vista municipality, Roraima	Capaverde-Júnior et al. (2014)
33	01°27′S	048°30′E	Belém, Pará	Bernard et al. (2001)
34	03°50′S	049°30′W	Tucuruí, Pará	Pine et al. (1996)
35	02°15′S	051°15′W	Floresta Nacional Caxiuanã, Pará	Marques-Aguiar and Aguiar (2002)
36	03°50′S	052°40′W	Altamira, Pará	Voss and Emmons (1996)
37	03°50′S	054°15′W	Parque Nacional da Amazônia, Pará	Marques (1985)
38	02°24′S	054°42′W	Santarém, Pará	Bernard (2001)
39	02°30′S	055°57′W	Alter do Chão, Pará	Bernard and Fenton (2002)
40	01°36′N	052°29′W	Parque Nacional Montanhas do Tumucumaque, Amapá	Martins et al. (2006)
41	01°40′N	051°10′W	Floresta Nacional do Amapá, Amapá	Martins et al. (2006)
42	00°02′N	051°03′W	Macapá, Amapá	Peracchi et al. (1984)
43	07°52′S	047°56′W	Palmeirante, Tocantins	Nunes et al. (2005)
44	10º58′S	055º 45′W	Médio Teles Pires, Mato Grosso, Brasil	Miranda et al. (2015)
45	01°24′S	045°46′W	Godofredo Viana Cândido Mendes, Maranhão	Lima et al. (2018)
46	08°01′S	034°56′W	State Park Dois Irmãos, Recife municipality, Pernambuco (present study)	Present study
47	08°00′S	035°01′W	Engenho Tapacurá, São Lourenço da Mata municipality, Pernambuco (present study)	Present study
48	10°46′S	037°01′ W	Refúgio da Vida Silvestre Mata do Junco, Capela municipality, Sergipe	Brito and Bocchiglieri (2012)
49	15°57′S	039°32′W	Itapebi, Bahia	Faria et al. (2006)
50	15°17′S	039°04′W	Una, Bahia	Faria et al. (2006)
51	19°25′S	040°03′W	Linhares, Espírito Santo	Peracchi and Albuquerque (1993)
52	23°12′N	044°50′W	Serra da Bocaina National Park, Paraty, Rio de Janeiro	Delciellos et al. (2018)

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